Prototype Zero Energy Studio

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Prototype Zero Energy Studio: A research-led, student-centred live build project

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Background

In 2011 the Department of Architecture and Planning at the University of Dundee embarked on a highly innovative interdisciplinary project to design and build a renewable powered, energy self-sufficient Passivhaus prototype at Dundee University Botanical Gardens. The remit was to develop design concepts and technical solutions for a small, ultra-low energy demonstrator that would address the broader requirements of the Scottish context in terms of sustainable living spaces, energy conservation, material resources, market-place and provide data on the building's performance (Figures 1-4).

The project initiated by Burford and Thurrott in the Department of Architecture and Reynolds and Rodley in the Division of Physics has involved two academic cohorts of students drawn from Architecture, Physics and Engineering in the conception, design and construction of the building. The project was intended to address the gap between the creative and technical aspects of traditional architectural and scientific pedagogy: the ability to understand the subtle relationship between technology and design and to use this understanding as a motivating force to inform and enrich the outcome of personal, problem-based learning.

Situated in the ‘real-world’ the studio was conceived to give students experience of the complexities of the professional context transferring knowledge and application of vanguard practice in ultra-low energy design. The work references a number of innovative ‘live’ academic exemplars that challenge the traditional pedagogy and polarized nature of architectural teaching, including Ghost Studios, Rural Studios, Neighbourhood Design/Build, Yestermorrow, Studio 804, Vlock Building Project, Wood Studio, Die Baupiloten and the Micro Architecture Unit. The innovative teaching model developed for the Macro Micro Studio advances this thinking, aligning studio-based ‘live-project-teaching’ with interdisciplinary, practice-led research, resulting in new creative and technical insights and outputs with broader relevance and wider application to the profession and industry.

Figure 1 West elevation

Figure 2 South east elevation

Figure 3 Interior ground floor

Figure 4 Interior upper floor

Project structure

The project was initiated from the outset as a collaborative, interdisciplinary research problem within Architecture and Physics, with the research centred within the design studio of the Department of Architecture and Planning's Macro Micro MArch unit. The architecture students' engagement with the project individually and as a team was through a continuous process of invention, development, testing and full-scale building. In parallel, individuals developed dialectic research studies that simultaneously contributed to the theoretical

thinking and were themselves informed by the central project. In addition, each student had a specific role and responsibility within the organisation and running of the project. In Physics and Engineering the MSc thesis studies ran in parallel with the architectural development informing the technical direction (Figure 5). The various research strands were brought together formally during regular project reviews and informally through tutor and student interactions. Additional academic contributors to the University team included Jones, Mackie and Smith (Engineering), Alasdair Hood and the University's Estates and Buildings Department, and Peter Wilson from the Forest Products Research Institute (FPRI) at Edinburgh Napier University. Buro Happold's Mike Barrett and Paul Roberts provided structural design advice and SER. Hardies provided CDMC compliance and McAlpines advised on site safety. Further contributions were made from external consultants informing specific aspects of the technical design. A steering group within the College of Arts and Social Sciences oversaw project management, health/safety and finance.

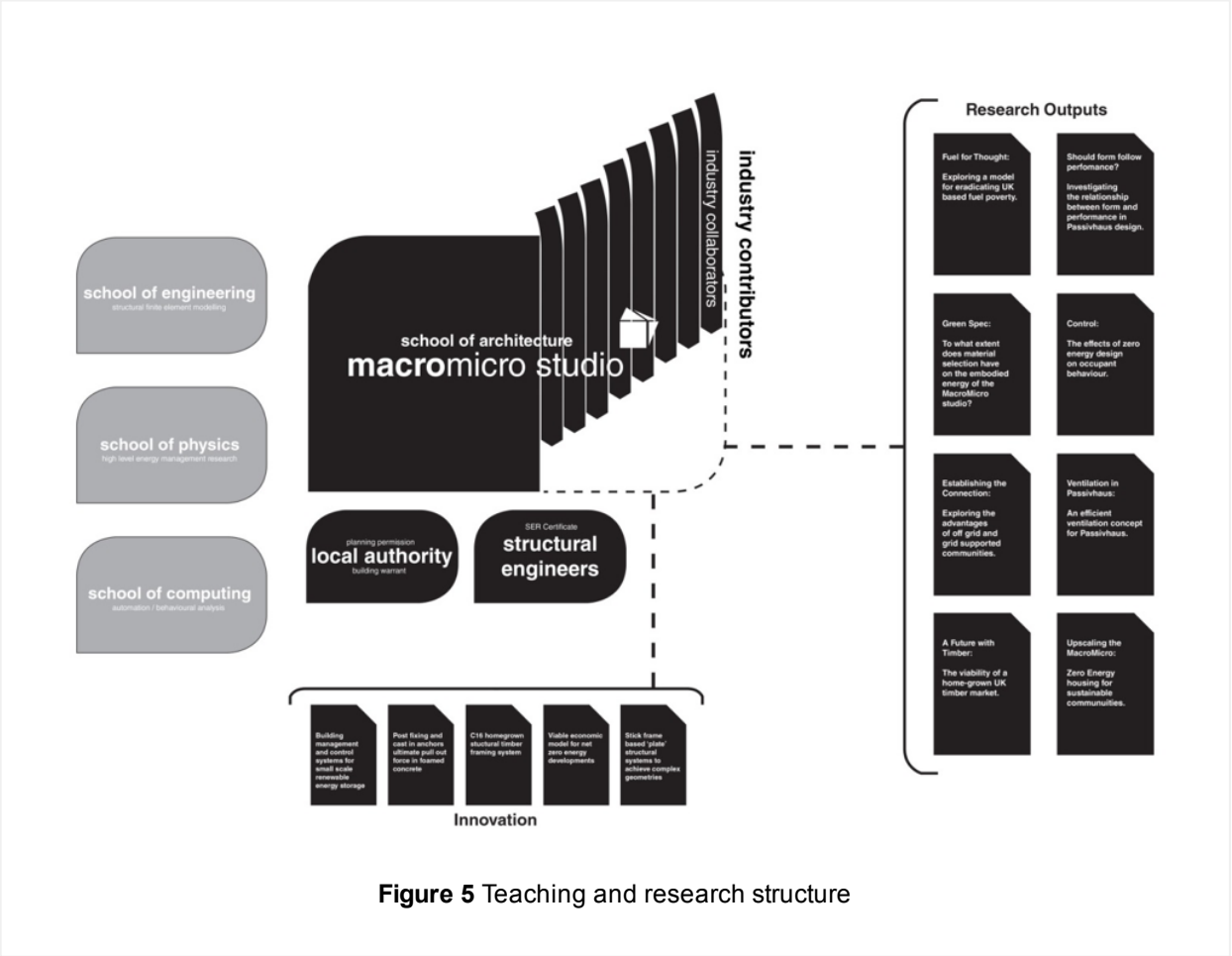

Figure 5 Teaching and research structure

Project funding

The project was funded primarily through industry in-kind donations of expertise and material. The main contributors were identified at the start of the project with the remainder being brought on board during the course of the project's development. It was apparent early on that capital funding would be required and after a failed Kickstarter bid, a business plan was developed around revenue generation from rental and FIT's income from the renewables. The University allocated £30,000 with a return on investment at the end of a three year period following completion. Additional funding was secured from the Scottish

Forestry Commission, Creative Scotland, Scottish Funding Council Innovation Awards and a number of charitable trusts. Grant funding was developed around discrete elements of research e.g. the visualisation of data and the integration of the renewables technologies, whereas charitable grants were used to pay for consumables and student labour beyond the end of the academic year.

Implementation

Between July 2011 and July 2012, the design was developed from concept to building warrant submission. This initial stage was based on a brief for a studio for an architectural masters unit of 12 students. The initial construction was based on a prototype small element CLT panel being developed by Napier University's FPRI. The energy strategies and the quantification of energy use defined the PV area, roof angle, battery store and wind turbine size based on predicted data. An important aspect of this work was an economic feasibility study which influenced the development of the business plan (Figure 6).

Figure 6 Exhibition of the work at the end of year 2011/2012

In the second phase from July 2012 to July 2013 the design was developed in response to an adapted brief (making the building suitable for letting commercially), an alternative construction method, and progressed to construction on site. The construction was changed from CLT to a lightweight frame requiring a reworking of the technical design and a new warrant application. The lightweight frame facilitated prototyping of the complex geometry and pre-fabrication of the timber kit in the safe environment of the Fulton Structures

Laboratory in Civil Engineering. Construction on site commenced with the pouring of an innovative air-in-trained concrete raft in January 2013 followed by the construction of the superstructure which was completed to watertight stage by August 2013. Thereafter, three students continued with internal fit-out until April 2014. The project is close to completion of the first phase and the securing of a completion certificate. Following this, further work will commence on the energy management, battery development and monitoring funded through major research grants (Figures 7-9).

Figure 7 Load testing fixings

Figure 8 Prototyping roof

Figure 9 Shell construction

Operational challenges

Students have been faced with a very steep open-ended learning curve requiring considerable cooperation across different disciplines and stakeholder groups and a shift in their mental map from academic to professional environments.

Team working with shared objectives and a single goal was a prerequisite which required students to commit to levels of responsibility, professionalism and workloads considerably beyond that asked of their peers.

Challenges running the project were exacerbated due to the fluid open-ended nature of the design as a result of having to train new student cohorts, lack of capital funding, uncertainty of industry contributions and the complex interdisciplinary/professional/industry interactions and timescales.

The highly experimental aspect of the design and technologies meant that many aspects of the project were unknown and with little previous precedent to refer to, increased the risk of failure. Some of these aspects such as the battery and energy management remain unresolved and require further major research investment.

Managing the design and construction of a high performance prototype, the health and safety issues associated with unskilled labour coupled to existing demanding academic workloads has resulted in compromises and delayed the completion of the project.

Outcomes

Having been immersed in an extremely challenging project environment students are better prepared for the complexities of practice and an increasingly complex and changing environmental and built environment context.

The project has reinforced the relevance and significantly enhanced the quality of sustainable and environmental teaching within the School at undergraduate levels and led directly to the development of an SFC funded interdisciplinary MSc in Zero Carbon Buildings.

The ambition of the project to find solutions to new and non-traditional problems in creative ways captured the interest of industry due to the potential for product development and the considerable exposure brought by the innovative design.

Significant impact has resulted from the work being nominated and winning several design awards, being used as exemplar best practice by numerous suppliers and press, professional and web based dissemination which has raised public and political awareness of energy efficiency and renewable energy requirements locally and nationally (Figure 10).

Figure 10 Scottish Funding Council Innovation Award Case Study 2015

References

Burford, N.K., and Pearson A.D., (2013). Ultra-Low-Energy Perspectives for Regional Scottish Dwellings, Intelligent Buildings International, Vol. 5, No. 4, Taylor and Francis,

London.

Edwards, B., (Ed) (2013), Rough Guide to Sustainability, Chapter 9 – Super Low Energy Houses, p220-240, 4th Edition, RIBA Publications, London.

Reynolds, Rodley and Burford, (2013). Prototype Energy Autonomous Studio In Dundee, Scotland, Proceedings of SEEP2013, Maribor, Slovenia.

Burford, N.K., (2013). RSA Open Architecture Exhibition, Edinburgh.

http://www.bdonline.co.uk/news/dundee-masters-unit-propose-self-build-project/5046875.article

http://inhabitat.com/macro-micro-studio-students-to-build-uks-first-net-zero-livework-studio-at-dundee-botanic-gardens/

http://plusmood.com/2012/12/timber-studio-macro-micro-studio/

http://www.jjijoists.co.uk/index.php/news/detail/james_jones_timber_systems_supports_first_net_zero_carbon_timber_structure.

http://www.itw-industry.com/news.php?newsid=138.

Burford, N.K., UK (2013). Timber in Construction Awards 2012-2013, Runner-Up, MacroMicro Group Study Prototype Zero Energy Building Botanic Garden, Dundee.

Burford, N.K., (2014) Dundee Institute of Architects, Small Project Award 2014.

Neil Burford

Dr Neil Burford is an architect and Senior Lecturer in the Department of Architecture and Planning at the University of Dundee. His interests are in the design of sustainable communities and low-energy housing which is supported by his teaching an MSc in Zero-Carbon Buildings and the MacroMicro© MArch design unit that undertakes live projects. His research is both practical and academic: as consultant, he was a finalist on the British Homes Awards, 2010 and was awarded 2nd place on the 100 Mile House competition, 2012. His most recent writings posit new concepts in sustainable rural housing and the relationship between housing energy efficiency and regional climate. During the early part of his career he developed and led an interdisciplinary research group in Lightweight Structures in collaboration with industry, practice and academia in the UK and abroad which resulted in a number of innovative award winning minimum energy structures. Currently he is leading a interdisciplinary consortia of academics and industry to design and build the UK's first zero-energy building at the Botanic Gardens, Dundee. This project addresses future regulatory changes and tests the

efficacy of decentralised micro-grids where buildings will become renewable energy power stations and energy stores of the future.

Carol Robertson

Carol Robertson is a lecturer in teaching and scholarship and a registered architect who has been engaged in education and practice for over 15 years. She joined the University of Dundee part-time in 2006 with several years' experience as a project architect, responsible for a range of projects including affordable housing, urban regeneration, community arts and small scale residential. Carol contributes to teaching, course development and assessment across all levels of the M.Arch course, and acts as an Examiner for the Architects Registration Board Part 1 and Part 2 examinations. Research interests include the relationship between form, space and material; sustainable, low energy communities and regional identity; live projects, peer learning and communication in architectural education. Carol holds a Postgraduate Certificate in Teaching in Higher Education, and is a Fellow of the Higher Education Academy. Her Postgraduate studies investigated peer learning, reflective learning, and live projects in architectural education through research, analysis and assessment of current teaching practice. Carol has contributed to the Live Projects Network, http://liveprojectsnetwork.org/, an online resource which aims to promote the use of live projects in education and share best practice through building relationships between students, educators, clients, practitioners and researchers.

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